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VANE-CELL PUMP PROVIDED WITH A DEEP-DRAWN SHEET METAL POT

[0001] The present invention relates to a pump, e.g., for conveying lubricating oil to an internal combustion engine, in particular a multi-stroke vane-cell pump in which a rotatable group includes a rotor having vanes that are movable at least in a radial direction, a stroke profile along which the vane heads slide tightly and two axial lateral lids in the form of lateral plates or casing walls.

[0002] Such pumps are known. Their lateral plates have axial inlet openings and outlet openings which must be separated by sealing devices or the like according to their pressure areas, for example, and therefore result in a great overall axial length in such vane-cell pumps. The components of the known rotatable groups such as lateral plates made of sintered steel and contour profile rings of solid steel or sintered steel are also accordingly designed with thick walls and thus require a great radial space as well as a great axial space.

[0003] The object of the present invention is thus to provide a pump which does not have these disadvantages.

[0004] This object is achieved by a pump, e.g., for conveying lubricating oil to an internal combustion engine, in particular a multi-stroke vane-cell pump in which the rotatable group has a rotor having vanes that are movable at least in a radial direction, a stroke profile along which the vane heads slide tightly and two axial lateral lids such as lateral plates or casing walls, the stroke profile and a first axial lateral plate being formed by a sheet metal pot. The sheet metal pot is preferably manufacturable by deep drawing. In addition, a pump in which a second axial lateral plate is formed by a sheet metal lid is also preferred. A pump according to the present invention is characterized in that the sheet metal lid has an embossed shoulder having an outside profile in the shape of the stroke profile. This has the advantage that after insertion into the sheet metal pot, the sheet metal lid covers the rounded edges of the sheet metal pot formed by the deep-drawing operation and thus creates a narrow sealing gap within the rotatable group. According to the present invention, the sheet metal lid may be manufactured by precision blanking or fine-edge blanking.

[0005] A pump according to the present invention is characterized in that the intake openings are formed by radial openings in the sheet metal pot. This has the advantage that the rotatable group has a narrow design because the suction channel may be situated around the sheet metal pot radially and need not be situated axially on the opposite side of the pressure channel.

[0006] A pump in which the outlet openings are formed by axial openings (pressure pockets) and optionally the at least one radial opening in the sheet metal pot is preferred. According to the present invention, the radial outlet opening is closable by a temperature switching valve or a pressure switching valve and thus establishes a switchable delivery area. This has the advantage that the pump delivers pressurized oil to both delivery areas as a function of the temperature-dependent or pressure-dependent lubricating oil demand for the internal combustion engine, or it conveys pressurized oil to only one delivery area, the second delivery area also going along without a pressure buildup, possibly resulting in a substantial power-saving effect.

[0007] A pump according to the present invention is characterized in that the temperature switching valve has an excess stroke spring. This has the advantage that after the radial outlet opening is sealed by the temperature switching valve and if there is no further expansion of a thermal expansion element due to an increase in temperature of the lubricating oil, the expansion element is able to execute an additional expansion movement against the excess stroke spring without any deformation or destruction.

[0008] In a preferred pump, the sheet metal pot of the rotatable group and possibly the temperature switching valve or pressure switching valve are integrated into a plastic casing. The plastic casing is preferably finished by injection molding and therefore does not require any reworking. The advantage here is that a rotatable group encapsulated in sheet metal is integrated into a plastic casing, making it possible to utilize the advantages of the two types of materials.

[0009] Another pump according to the present invention is characterized in that the axial outlet opening of the switchable conveyor area is closable by a reed nonreturn valve. The reed nonreturn valve has the same shape as the stroke profile curvature. The reed nonreturn valve is also mounted on a journal made of plastic in the plastic casing. The reed nonreturn valve is also

protected from overstrain by a stroke stop in the plastic casing. This design of the reed nonreturn valve has the advantage of being very inexpensive while also being integrated into the pump in a neutral manner in terms of space.

[0010] A pump according to the present invention is characterized in that the sheet metal pot has a notched or impressed cold start ring, which guides the vanes outward according to the stroke profile beneath the vanes in a cold operating state and steers against the stroke profile. In addition, a pump in which the rotor has grooves or indentations to receive the cold start ring is also preferred. In another preferred pump, the sheet metal lid has a notched or impressed cold start ring.

[0011] A pump according to the present invention is characterized in that the sheet metal lid has apparent pressure pockets impressed in it, i.e., pressure pockets without through-openings which produce only an axial pressure surface compensation for the rotor in the pressure area.

[0012] In another preferred pump, the radial outlet opening(s) of the switchable delivery area open(s) into a channel opening directly by a short path into the intake area of the second nonswitchable delivery area. This has the advantage that low flow losses and a favorable channel guidance result in a low-energy pressureless circulation in the switchable delivery area.

[0013] The present invention will now be described in greater detail on the basis of the figures.

[0014] Figure 1 shows a view of the open pump.

[0015] Figure 2 shows section B-B from Figure 1.

[0016] Figure 3 shows a cross section of the sheet metal pot and the rotor.

[0017] Figure 4 shows a detail of the sheet metal pot and the sheet metal lid.

[0018] Figure 5 shows a cross section of the rotatable group and the temperature switching valve.

[0019] Figure 6 shows a cross section of the temperature switching valve in the open state.

[0020] Figure 7 shows the pump casing having the nonreturn valve.

[0021] Figure 8 shows section D-D from Figure 7.

[0022] Figure 9 shows section C-C from Figure 7.

[0023] Figure 10 shows a cross section of an embodiment of the cold start ring.

[0024] Figure 11 shows a cross section of another embodiment of the cold start ring.

[0025] Figure 1 shows a top view of the pump according to the present invention in its casing without the cover. Sheet metal pot 1 in which the stroke profile is designed contains the other parts of the rotatable group such as vanes 3, which are displaceably situated in radial slots 5 in rotor 7. Rotor 7 has a recess 9 in which for example the crankshaft of an internal combustion engine engages and thus drives the lubricating oil pump. This is referred to as a neck-of-shaft pump. The rotatable group is situated together with sheet metal pot 1 in a plastic casing 11 and is sealed by the sheet metal lid (not shown here). The rotatable group, completely encapsulated in sheet metal, thus has the advantage that there is no change in friction pairing. There are no sliding movements against plastic parts, so that low-wear operation is possible. Sheet metal pot 1 is partially surrounded inside plastic casing 11 by a channel 13, which is subjected to the intake pressure of the pump. Due to the shape of the stroke profile, two pressure areas 15.1 and 15.2 in which the cells between the vanes, rotor, lift ring and lateral plates become smaller and thus eject the pressure medium, and two intake areas 17.1 and 17.2 in which the corresponding cells become larger and thus draw in the medium, are formed inside the rotatable group. The function of such a double-stroke vane-cell pump is known and need not be explained further here. Inside the casing, there is also a temperature switching valve 19 which has an expansion element inside

a casing 21, this expansion element being able to press a valve compression plate 25 against sheet metal pot 1 via a pin 23 against the force of a restoring spring 27 when there is a temperature increase in the lubricating oil. In sheet metal pot 1, there is a radial opening (not shown here) from which pressure pocket 15.1 is able to convey pressurized oil into intake channel 13 as long as the temperature switching valve remains in this open state. The oil ejected by pressure pocket 15.1 thus goes through channel 13 to intake pocket 17.2 of the second half of the pump in a pressureless operation, thus permitting oil intake by the pump without any great losses. Sheet metal pot 1 therefore has one or more radial openings in the intake area of suction pocket 15.2. Likewise, suction pocket 17.1 of the first pump part has radial openings (not visible here) in sheet metal pot 1 through which oil may be drawn in from suction channel 29. Suction channel 29, like suction channel 13, is connected to intake connection 31 from which the oil may be drawn in from the area of the internal combustion engine, e.g., the oil pan. The oil is then ejected via the lubricating oil pump in pressure channel 32 and sent under pressure through pressure connection 34 to the internal combustion engine. A pressure-limiting valve (not shown here) is provided in area 36 of the plastic casing and when the maximum allowed pressure in pressure area 32 is exceeded, this valve opens and the excess oil flows through outflow channel 38 back to intake area 29.

[0026] Figure 2 shows section B-B from Figure 1. Sheet metal pot 1 is embedded in plastic casing 11. Sheet metal pot 1 contains the rotatable group and thus, among other things, rotor 7, a cross section of which is shown here. The rotatable group is sealed by a sheet metal lid 40. In the case of sheet metal pot 1, the stroke profile is shaped directly into the sheet metal, as illustrated in Figure 1, and sheet metal bottom 42 of the sheet metal pot forms the first axial lateral plate of the rotatable group. Lid 40 has a shoulder 44 protruding into the upper edge of sheet metal pot 1, also having the shape of the stroke profile in its outer profile and thus forming the second axial lateral plate of the rotational group. To improve the intake capacity of the pump, multiple radial openings 46 and 48 are introduced into sheet metal pot 1 in the suction area. Intake openings 46 and 48 open into intake channels 29 and 13, a top view of which is shown in Figure 1.

[0027] Figure 3 shows a detailed view of the design of sheet metal pot 1 in plastic casing 11 and rotor 7. This shows that the upper end of sheet metal pot 1 has a rounded area 50, which is

created by the manufacturing technology involving the deep-drawing operation. On its lateral faces, rotor 7 has two grooves 52 in which cold start ring 54 engages. Cold start ring 54 is notched or impressed out of sheet metal pot 1 and is also in the shape of the stroke profile on a reduced scale. This cold start ring thus grips in rotor grooves 52 under the vanes and lifts them along the shape of the profile so that they slide approximately along the contour ring and seal it, even when the vanes are not pressed out beneath the vane by centrifugal forces or by additional compressive forces. Reliable contact of the vane heads with the contour ring is thus ensured even during a cold start and at low rotational speeds.

[0028] Figure 4 shows in particular how sheet metal pot 1 works together with sheet metal lid 40 in detail. Due to the manufacturing procedure, rounded area 50 is formed by the deep-drawing operation on sheet metal pot 1, but this area would be problematical as a sealing surface or as a running surface for the vanes. Therefore, sheet metal lid 40, which may be manufactured as a flat part using a manufacturing method other than deep drawing, has a sharper-edged shaping of shoulder 44, which covers rounded area 50 and thus ensures an adequate seal of the rotatable group on the top side of rotor 7 and the vane heads. The vanes and their lateral walls and their vane head are thus also accommodated inside the rectangular rotatable group space in a sufficiently sealed manner.

[0029] Figure 5 shows a cross section of the rotatable group and the temperature switching valve. The same parts are labeled with the same reference numbers and will not be explained again here to avoid repetition. The temperature switching valve is extended due to the increased temperature of the lubricating oil in this diagram, sealing with its valve body 25 an opening 56 in the pressure area. As a result, pressure pocket 15.1 from Figure 1 is unable to convey oil into the pressureless circulation of the channel 13 and thus conveys it via a nonreturn valve 64, to be explained in greater detail below, into pressure channel 66, so that the two pressure pockets meet the lubricating oil demand of the internal combustion engine. Temperature switching valve 19 is accommodated together with the casing of expansion body 21 in a separate lid 62, where the expansion element casing 21 is supported together with an excess stroke spring 58 on a web 60 of lid 62. Excess stroke spring 58 secures the expansion element and the casing against overstraining due to a further increase in temperature and expansion of the expansion element,

which functions as follows: First, with an increase in temperature, the expansion element causes operating rod 23 to be extended against the force of spring 27 and thus pressure opening 56 is sealed by valve body 25. Spring 27, which functions as a restoring spring for the expansion element after cooling and moves the temperature switching valve back into the open position, is surrounded by a spring pot 68 which simultaneously functions as a guide for rod 23 here. If there is further expansion of the expansion element while the temperature switching valve is closed, the expansion element may yield toward the rear against stop 60 against the force of excess stroke spring 58 and thereby prevent destruction of the expansion element or the casing part supporting the expansion element.

[0030] Figure 6 shows the temperature switching valve in the open state, i.e., in the cooled state. Valve closing body 25 has moved a distance away from radial pressure opening 56 of sheet metal pot 1 and the pressurized oil from area 15.1 is then able to flow through opening 56 into channel 13 for pressureless circulation up to intake pocket 17.2 from Figure 1. Here again, spring pot 68 also guides operating pin 23 of the temperature switching valve. Restoring spring 27 has pressed the operating pin and the cooled expansion element back via spring pot 68.

[0031] In Figure 7 the rotational group from Figure 1 has been removed, so that the arrangement of nonreturn valve 64 is discernible in an underlying pressure channel 70. Pressure channel 70 and spring plate 72 of nonreturn valve 64 are adapted to the stroke profile, so that spring plate 72 of nonreturn valve 64 is able to close pressure pocket 15.1 from Figure 1. Nonreturn valve 64 is mounted on a plastic pin 74 in casing 11 and is secured thereby with respect to the plastic casing after inserting the sheet metal pot.

[0032] Figure 8 shows section D-D from Figure 7 and thus stroke end stop 76 of valve blade 72. In section C-C, Figure 9 shows plastic pin 74 which supports spring blade 72 in plastic casing 11.

[0033] Figure 10 shows a cross section of an alternative version of cold start ring 54.1 in comparison with the version of cold start ring 54 in Figure 3. Cold start contour 54.1 is pressed

out of sheet metal pot 1 by blanking and thus engages beneath vane 3 which is situated in lift ring 7 and thus guides vane 3 along the stroke profile of sheet metal lid 1.

[0034] Figure 11 shows another variant of cold start contour 54.2, which is manufactured by displacement of material out of sheet metal pot 1, and thus, here again, is able to guide vane 3 toward the profile.

[0035] During assembly, sheet metal lid 40 is pushed onto sheet metal pot 1 (see Figure 2) and then attached by a welding operation. This procedure offers several advantages:

1. The axial tolerances of the pot depth may be eliminated if the attachment of lid 40 is performed in a path-controlled procedure.

2. In the transition from the stroke profile to the sheet metal flange, a radius 50 (see Figure 3), which would be harmful for the volumetrics of the rotatable group, is formed on sheet metal pot 1 by the deep-drawing operation. In positioning shoulder 44 of lid 40, radius 50 is removed from the function area of the rotatable group. One advantage of the encapsulated rotatable group is that all important profiles for the control times are integrated and the positioning of the complete rotatable group in plastic casing 11 allows greater tolerances.

[0036] Axial and radial openings are provided in the pressure area of the switched stage. The openings in the radial direction with the temperature switching valve or a pressure switching valve are used for pressureless circulation. In doing so, the oil is flushed back out of the pressure side and into the intake space for intake of the next suction stage. The thus obtained channel guidance yields only minor flow losses due to deflection.

[0037] The great advantages of this pump design having corresponding radial and axial openings include the reduction in the required space as well as the cost savings.